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Measurement of Impedance of Magnetic Heads

in Conducting an Inspection on the Production Line and Assessing Device Characteristics



Application Note 369-12

The HP 4285A Precision LCR Meter



In order to accurately check the quality of magnetic heads to satisfy these requirements, it is necessary to conduct measurement under the conditions close to actual operation in terms of operating frequency and applied current. For this purpose, it is important to conduct measurement at constant current and to accurately measure the impedance value even at high frequencies. An LCR meter used for measurement of magnetic heads is required to measure at constant current and at a wide range of frequencies. As well as being highly accurate, it must be easy and cost effective to use. Development of a measuring device satisfying all these requirements at frequencies over 1 MHz had been long awaited.

(Table 1 shows "Applications of Magnetic Heads, Typical Operating Frequency and Measurement Range for each Application")

This application note will present solutions which make use of the HP 4285A, when such magnetic heads operating at relatively high frequencies are inspected on the production line, and assessed for their device characteristics.

Preface

The market for magnetic heads is expected to experience further expansion due to a wide variety of industrial applications as well as consumer electronic applications. In consumer electronics, the VTR (video tape recorder) market forms a large market for magnetic heads. The digital VCR (video cassette recorder) and VTR markets are expected to expand, benefiting the magnetic head market. In the industrial field, along with the market expansion of computer-related devices, the market for both hard and floppy disks has continued to grow. In

addition, there is a high demand for tape drives used for computer back up.

In these areas, magnetic heads will be required to operate at higher frequencies to provide higher quality. The movement towards higher picture quality, demonstrated in S-VHS's and even higher picture quality in higher grade VTR's, demands magnetic heads to record and read signals at higher frequencies. Hard and floppy disk drives process a massive amount of data, thus requiring high speed and high density recording and reading of the data.

| Application of Magnetic Heads | Typical Operating Frequency | Measurement Range for each Application | Measurement at Constant Current |
|-------------------------------|-----------------------------|--|-------------------------------------|
| Audio Head | 12.5 KHz | 1 KHz | 100 uAp-p |
| VHS Head | ~5 MHz | 5 MHz | 100 uAp-p |
| High8 VCR head | ~7.7 MHz | 5 MHz | 1 mAp-p |
| High Definition VTR Head | 20M~76 MHz | Various | Various |
| Professional Digital VCR Head | 30~40 MHz | Various | Various |
| 6mm Digital VCR Head | ~22 MHz | 10 MHz | 40 mAp-p |
| Thin Film Head | ~40 MHz | 1 MHz | 30~40 mAp-p |
| MR Head | ~100 MHz | 1 MHz | 10~14 mAp-p(MR) 30~40 mAp-p(Ind) |
| Floppy Disk Head | ~100 KHz | 1 KHz | 4~7 mAp-p |
| DDS-DAT Head | ~5 MHz | 5 MHz | 24 mAp-p |

Table 1. Application of Magnetic Heads, Typical Operating Frequency and Measurement Range

How to Use an LCR Meter for Measuring Magnetic Heads

When magnetic heads are assessed using an LCR meter, the following items are normally measured. The objectives for measurement and assessment are also listed in the following.

• The Items to be Measured and Conditions for Conducting Measurement of Magnetic Heads on the Production Line

A. The Items Measured

1) L (Inductance)

Compared with the prescribed value obtained from data on magnetic heads of good quality, check for any abnormality.

- Measurement objectives
 - a) Checking for defects or flaws of the magnetic head materials
 - b) Checking for the number of coil turns
 - c) Checking for abnormal configuration including the width of head gap

2) Q (Purity of reactance)

- Measurement objective
Assessment of losses such as eddy-current loss

3) |Z| - θ (Impedance)

Compared with the prescribed value obtained from data on magnetic heads of good quality, check for any abnormality in the materials and/or configuration of magnetic heads.

- Measurement objective
Checking for the resonant frequency

B. Measurement Conditions and Method

- Conducting measurement at constant current (The constant current should be applied in conducting measurement because the magnetic head characteristics change depending on the current level.)
- Covering the range of frequency required for measuring magnetic heads and providing high accuracy
- Go/No-Go measurement (Measurement to see if a magnetic head operates or not.)
- Interface available for measuring scanners which are capable of multidevice measurement

• The Items Measured and Conditions for Assessing the Magnetic Head Characteristics

In addition to the items and conditions for measurement on the production line mentioned above, assessment of device characteristics requires the following:

- Sweep measurement at multiple frequencies
- Selection of multiple measurement parameters
- Flexible setting of measurement conditions such as frequencies to be measured at and the input level of voltage, current and electric power

Problems of Conventional Devices used for Measuring Magnetic Heads, and Solutions brought by the HP 4285A and its Features

The HP 4285A's special features will provide a powerful solution to each problem conventional magnetic head measuring devices face.

1) Measurement at Constant Current

For accurate assessment of magnetic heads, impedance must be measured at constant current because the inductance value of a magnetic head changes depending on the current level. Most conventional measuring devices do not allow measurement at constant current when the frequency is over 1 MHz. Even when this is possible, you might find them unsatisfactory, because you cannot select the value of constant current.

The HP 4285A is equipped with Automatic Level Control (ALC). This ALC function allows you to set the current level (100 μ A-20 mA) as you wish. Once you set the level, the HP 4285A automatically controls the current, thus making it easy to perform measurement of magnetic heads at constant current.

2) A Wide Measuring Range of Frequency and High Accuracy

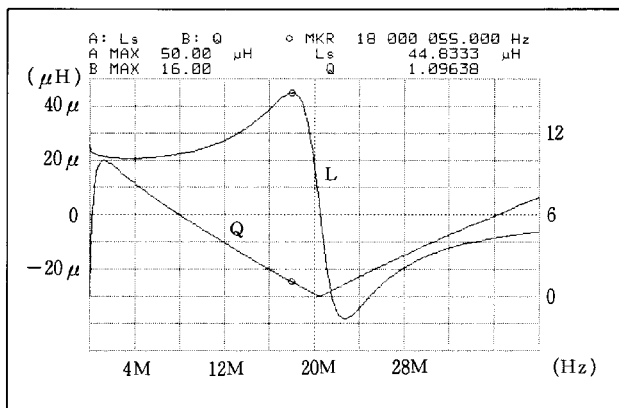
With conventional LCR meters, it is technically difficult to measure with high accuracy at high frequencies up to tens of MHz.

The HP 4285A performs measurement at a wide range of frequency ranging from 75 kHz to 30 MHz, and ensures high accuracy within 0.1%. It is equipped with a powerful error correction function called "Open/Short/Load" to eliminate the error residual of the testing device.

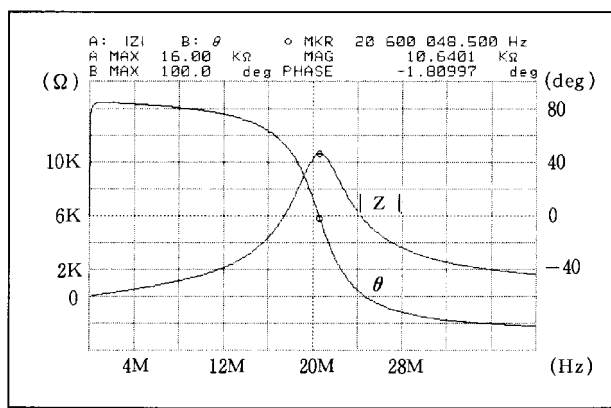
3) Easy-to-use Functions on the Production Line, including Go/No-Go Measurement

In order to save time and labor for switching devices before manufacturing a new lot on the production line, it is essential that a device allow as simple set-ups as possible, including a set-up of measurement conditions. The device is also required to recognize if a magnetic head is operating as desired or not.

The HP 4285A is capable of storing ten sets of set-up information such as measurement conditions in its internal memory, and ten more sets on a memory card. This feature permits easy set-up for measurement on the production line. In addition, the HP 4285A is equipped with a variety of functions useful for production such as a simple, flexible set-up of Go/No-Go measurement and BIN's. An interface is available to accommodate scanners and handlers.



Graph 1. Inductance Characteristics of the Magnetic Head Frequency (HZ) (Measured using the HP 4194A)



Graph 2. Impedance Characteristics of the Magnetic Head Frequency (HZ) (Measured using the HP 4194A)

4) Sweep Measurement at Multiple Frequencies

A measuring device used for assessment of magnetic head characteristics needs to have a function which specifically selects multiple frequencies for sweep measurement.

The HP 4285A allows sweep measurement by entering up to ten frequencies of your choice. It also presets the limit to the measured value for every frequency selected, thus allowing easy Go/No-Go measurement.

5) Setting up Flexible Measurement Conditions

Assessment of magnetic head characteristics requires setting up flexible measurement conditions. The HP 4285A has twenty combinations of preset measurement parameters. Thus, you only need to choose one. You can enjoy flexibility of setting up measurement conditions such as the frequency to be measured, the input voltage/current level and the direct current bias.

An Example

The measurement functions of the HP 4285A will be presented using measurement of hard disk magnetic heads as an example.

1) The Hard Disk Magnetic Heads Measured and their Characteristics

- a) Device measured: hard disk magnetic heads
- b) Device characteristics

The impedance characteristics of the hard disk magnetic heads measured ($L_s - Q, |Z| - \theta$) are shown in graphs 1 and 2. (Measured using the HP 4194A.)

In measuring magnetic heads on the production line, their characteristics are not measured at all levels of frequency. Instead, the actual method used is designed to achieve high measurement efficiency. As mentioned above, the method determines Go or No-Go by measuring the value of parameters at specifically selected frequencies and setting up limit values.

2) Set-up for Measurement

The set-up for measurement is shown in diagram 3.

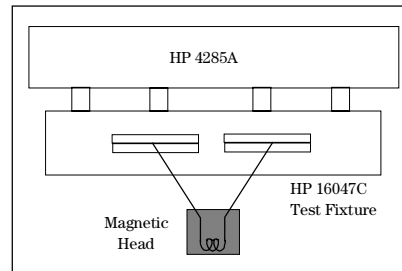


Diagram 3. Set-up for Measurement

3) Results

The hard disk magnetic heads used in assessment of inductance and impedance characteristics demonstrated in graphs 1 and 2 were measured using the HP 4285A, equipped with special features such as a sweep measurement function at flexible frequencies, a Go/No-Go measurement function and a BIN function. The results are described in the following.

Chart 4 shows the results of sweep measurement in which the inductance characteristics $L_s - Q$ are measured at ten selected frequencies. Chart 5 shows how to set up frequencies to be measured at, and the high and low limit values. On the display <LIST SWEEP SETUP> as shown in Chart 5, the selected frequencies to be measured at are set up in the FREQ [Hz] column, the high and low limit values needed for Go/No-Go measurement are entered for each frequency level in the HIGH and LOW columns, and the selected measurement parameter in the LMT column.

<LIST SWEEP DISPLAY> as shown in the chart 4 displays the measurement results at each frequency level and the results of Go/No-Go measurement in the CMP column. Chart 6 displays the results of binning in which the devices are measured for their impedance value $|Z|$ at a specific frequency, and then classified into the nine preset bins (BIN's 1 through 9) or OUT OF BINS. The desired impedance value is set in the NOM column, and the lower and upper limit values from the desired value are set for the BIN's 1 through 9 in the LOW and HIGH columns, respectively.

The COUNT column shows the number of devices classified into that bin. The lower and upper limit values can be entered by the absolute value as well as by percentage, which allows flexible setups. The limit value of θ used as the second parameter can also be set in the row labeled "2nd."

Conclusion

A magnetic head measuring device must have a function which maintains constant current. The HP 4285A allows you to set up any specific value of constant current within the range of 100 μ A-20 mA, and to automatically control it. Furthermore, the HP 4285A is equipped with a function to measure magnetic heads with high accuracy even at high frequency (75 kHz -30 MHz) which cannot be covered by the conventional LCR meters. In addition to this feature, it is also equipped with a Go/No-Go function, a memory card, and several functions which make it easy to use the device on the production line. Therefore, the HP 4285A is the most suitable device for performing measurements on magnetic heads operating at relatively high frequencies. This LCR meter also serves various other purposes, including measurement and assessment of magnetic storage components such as rotary transformers used in VTR's.

The HP 4285A offers powerful solutions to problems that conventional LCR meters cannot overcome in measuring magnetic heads. The HP 4285A is furnished with functions ranging from production line inspection to assessment of device characteristics.

If a device must be measured at higher frequencies due to its higher operating speed, the HP 4219A RF impedance/material analyzer or the HP 4286A RF LCR meter may best suit your needs.

```

<LIST SWEEP DISPLAY>      SYS MENU
HARD DISK MAGNETIC HEAD Ls-Q
MODE : SEQ
FREQ[Hz]  Ls[ H ]      Q[ ]  CMP
* 1.0000M  21.0290u      19.6  H
10.0000M  24.2116u      4.92
14.0000M  31.3683u      2.85
16.0000M  38.4221u      2.02
18.0000M  42.7488u      1.09  L
20.0000M  24.0278u      0.30  H
22.0000M  -32.4840u      0.55
24.0000M  -34.9042u      1.43
26.0000M  -25.9030u      2.07
30.0000M  -14.8492u      3.72  H

```

Chart 4. Sweep Measurement Results of Ls - Q, and Go/No-Go Measurement Results

```

<LIST SWEEP SETUP>      SYS MENU
HARD DISK MAGNETIC HEAD Ls-Q
MODE : SEQ
FREQ[Hz]  LMT      LOW      HIGH
1.0000M  A      15.0000u  20.0000u
10.0000M  A      21.0000u  26.0000u
14.0000M  A      29.0000u  36.0000u
16.0000M  A      36.0000u  41.0000u
18.0000M  A      44.0000u  45.0000u
20.0000M  A      15.0000u  19.0000u
22.0000M  A      -40.0000u -30.0000u
24.0000M  A      -40.0000u -30.0000u
26.0000M  A      -30.0000u -20.0000u
30.0000M  A      -20.0000u -15.0000u

```

Chart 5. Setting up Ls - Q Sweep Measurement Frequencies and Go/No-Go Limit Values

```

<BIN COUNT DISPLAY>      SYS MENU
FUNC : 2-0 deg NOM : 134.900
BIN  LOW [ % ]  HIGH [ % ]  COUNT
1 - 0.025 + 0.025      120
2 - 0.050 + 0.050      24
3 - 0.075 + 0.075      18
4 - 0.100 + 0.100      8
5 - 0.125 + 0.125      0
6 - 0.150 + 0.150      0
7 - 0.175 + 0.175      4
8 - 0.200 + 0.200      0
9 - 0.225 + 0.225      0
2nd + 60.000 +120.000 [deg]
REJ CNT AUX: 0      OUT: 18

```

Chart 6. Results of BINNING based on the Impedance Value $|Z|$

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